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PEDOLOGICAL EVALUATION AND CLASSIFICATION OF AGRICULTURAL LAND IN TÂRNOVA COMMUNE, ARAD COUNTY, AND IMPORTANCE FOR SUSTAINABLE RESOURCE MANAGEMENT

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Abstract. *This study offers a comprehensive pedological assessment of soils and agricultural land in the commune of Târnova, Arad County, with the main goal of promoting sustainable natural resource management and supporting the long-term development of the local agricultural sector. Through an integrated approach combining field observations, detailed laboratory analyses, and interpretation of pedo-structural data, the research identifies and classifies the region's dominant soil types, including alluviosols, eutric cambisols, preluv sols, vertisols, and gleysols. Each soil class features unique characteristics that are shaped by geomorphological, hydrological, and climatic influences, which directly impact their agricultural suitability and require specific management practices. The surveyed agricultural lands cover over 55% of the area, mainly consisting of arable lands, with smaller proportions dedicated to pastures and hayfields. Morphological studies highlight the complexity and variability of pedogenic horizons, while evaluations of fertility, structural integrity, and water retention capacity provide essential insights for developing efficient and sustainable farming practices tailored to local environmental conditions. The findings contribute significantly to expanding and updating the regional pedological database, serving as a vital resource for land management authorities, environmental conservation efforts, and farmers alike. Ultimately, this detailed assessment supports responsible land use planning, promotes sustainable agriculture, and helps ensure economic growth and environmental protection in the region over the long term.*

Keywords: *soils, taxonomy, management, potential, sustainability*

INTRODUCTION

This study aims primarily to assess the pedological characteristics and classify the agricultural lands of Târnova commune, Arad County, as well as to analyze the importance of these activities for sustainable natural resource management. In the current context, soil resource management has become a major priority for environmental conservation and for ensuring efficient and sustainable agriculture. Therefore, it is essential that methods and systems for soil characterization and classification evolve in accordance with new technologies and scientific approaches to provide precise and relevant data for decision-making.

The evolution of pedological science reflects a historical trajectory in which empirical perceptions and observations based on local knowledge have gradually been replaced by rigorous scientific approaches supported by modern technologies. Starting with the first classifications of soils made by researchers from various international schools, such as German, Russian, or American, the process has advanced toward a system based on morphological, chemical, and mineralogical properties. These efforts culminated in the creation of the first national soil maps in Romania during the early 20th century (Bocioacă, 2015). This process was crucial for establishing a solid database, which is essential for the sustainable management of agricultural land.

A significant technological revolution occurred with the advent of digital technologies and information systems, such as Geographic Information Systems (GIS), satellite remote sensing, and data digitization techniques. These innovations allow the creation of highly accurate soil maps, with capabilities for real-time monitoring of changes and identification of sensitive zones, such as areas affected by degradation or desertification (Šimanský et al., 2018). Furthermore, artificial intelligence and machine learning models, such as Random Forests or neural networks, open new perspectives for automatic land classification, even under conditions of incomplete or highly variable data. These advanced methods ensure higher accuracy and enable predictions for inaccessible or extensive zones, thereby facilitating the planning and implementation of effective and ecologically responsible agricultural and soil conservation policies (Santos et al., 2020).

Within this modern framework, the international reference system for soil classification, the World Reference Base for Soil Resources (WRB), becomes an essential tool for ensuring comparability and effective communication of results. The WRB system, which is based on objective and field-observable criteria such as color, texture, pH, profile features, and pedogenetic processes, provides a unified and comparable classification at the global level (FAO & UNESCO, 2015). In the specific context of Târnova, applying this system, along with the use of national systems such as S.R.T.S. 2012, will enable accurate characterization of agricultural lands, thus supporting the development of management plans tailored to local particularities.

The importance of this research stems from the crucial role that soil plays in maintaining a balance between agricultural development and natural resource conservation. Through rigorous assessment and appropriate classification of land, it becomes possible to identify areas with high potential, as well as vulnerable or degraded zones, thereby facilitating the implementation of conservation, regeneration, and sustainable utilization measures (Diner et al., 2018). The agricultural lands of Târnova, contributing significantly to the local economy, must be managed responsibly to ensure food security and ecosystem health.

MATERIALS AND METHODS

This research aims to develop a comprehensive pedological data bank that serves as a scientific foundation for the adoption of the most effective technological measures, tailored to the specific characteristics of each studied area. The main objectives of this scientific endeavor can be summarized as follows:

Identification, delimitation, and inventory of soil-vegetation units within the study area;

- Morphological, physical, hydro-physical, and chemical characterization of these units in accordance with cartographic data;
- Highlighting the nature and severity of natural and anthropogenic factors that limit or constrain the potential for agricultural productivity.

To achieve these objectives, the study was based on data obtained from both direct field observations and laboratory analyses, as well as from archives of the Pedological and Agrochemical Survey Office of Arad (O.S.P.A.), ensuring a solid and diverse data foundation.

During the process of identifying and delimiting soil units, multiple pedological profiles were excavated and analyzed, from which samples were collected under both natural conditions and circumstances of land modification caused by human activities. These profiles were strategically positioned in representative zones of the terrain to characterize the most relevant soil types and subtypes.

For a comprehensive characterization, specific pedological methods were employed, including soil mapping, morphological description, rapid in-field determinations, laboratory analyses, and data processing and interpretation. Based on recent data obtained via direct observation and subsequent processing, genetic soil types within the study area were identified and classified. These profiles were strategically placed in representative zones to highlight the most important soil types and subtypes, according to both national and international classification systems.

Samples for physic-mechanical characterization were collected under controlled conditions, using metal cylinders of known volume, at the soil moisture content present at the time of sampling, and

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stored in special containers for micro-morphological analyses. Simultaneously, samples for chemical analyses were stored in plastic bags for each genetic horizon and analyzed using standard methods.

To determine specific chemical parameters, agrochemical techniques were employed, with sampling performed from the processed layer of the profile, following current agricultural methodologies. Morphological description and ecopedological assessment were carried out in accordance with the Soil Taxonomy System of Romania (2012), supplemented and adjusted according to the "Methodology for Developing Pedological Studies" (Volumes I, II, and III, 1987), developed by the Pedological and Agrochemical Research Institute (ICPA) in Bucharest.

The research results led to the identification and delimitation of a significant number of genetic soil types within the study area, with profiles strategically placed in representative zones. These allow for the description and classification of the most important soil types and subtypes, in line with both national and international systems, and are highly useful for application in agricultural planning, environmental protection, and land improvement.

RESULS AND DISCUSSIONS

1. THE NATURAL FRAMEWORK OF FORMATION AND EVOLUTION OF SOILS IN TÂRNOVA COMMUNE, ARAD COUNTY

1.1. Relief and Geology

The territory lies within the eastern marginal zone of the Crișurilor Plain, extending along the depressional corridor of the Crișul Alb River (Zărand-Ineu depression gulf) and within the basin of the Cigher River. This boundary of the plain is sinuous and difficult to delineate precisely due to the nearly imperceptible interference between the plain and the terminated alluvial terraces (terraces and lower glacis), which belong to the hilly zone. The contact is roughly marked along the localities of Mocrea, Moroda, and Pâncota. Variations in elevation have largely been subdued owing to anthropic activity.

In terms of relief, there have been attempts to distinguish elevated forms such as the fan-shaped glacis and the lower alluvial terraces (arranged in a westward decline to altitudes of 117-115 meters), which gradually fade into the broader plain. The formation of these steps was primarily conditioned by the retreat of the Pannonian Lake's base level to the west, accompanied by several stages of slow regression and periods of stability. The shoreline retreat (gradual formation of the plain from east to west) was caused by subsidence and a negative hydrological balance. Neotectonic movements and intensified subsidence disrupted the existing equilibrium, resulting in intense erosion in the piedmont zone and sediment accumulation in the shoreline area, due to changes in slope inclination.

Initial sediment accumulation occurred submersively, characterized by the development of submerged cones that later transformed into deltas. On the newly formed surfaces, erosion and lateral migration of small rivers occurred, leading to the formation of glacis plain steps.

Relatively low terraces (5-8 meters) and the inferior glacis are located in the eastern half of the territory. Sediment accumulation happened during the last glaciation, while post-glacial sculpting took place during a moist period situated between the cold-dry era (associated with fir and birch forests) and the dry-warm era (linked to oak forests), representing a middle-altitude plain step at 110-117-120 meters. The average fragmentation is 0.5 km/km². Valleys are less articulated or broad, often with marshy areas, and interfluvial plains are low and flat, with frequent bogging processes.

This relief level includes the prolongation of the Mocrea and Pâncota hills, characterized by gentle slopes nearing imperceptibility, gradually merging into alluvial terrace levels. Transitions from one terrace to another are generally poorly defined due to colmatation with deluvio-pluvial deposits and the long-lasting practices of agriculture.

The inferior glacis, considered part of the high piedmont plain, exhibits weak common features with it but shares many affinities with the low plain, where alluvial processes dominate. A series of small valleys (valleys or "vâlcele"), some barely outlined and others more developed, with broad valleys up to several meters wide and maximum relief energy of 2-3 meters, can be distinguished. At the contact with the plain, there are marshy zones and small lakes.

In other parts of the plain, higher terrain islands at approximately 110 meters indicate that the glacis was once more extensive but have been largely removed by subsequent erosion. Quaternary Pleistocene deposits consist of clays, clayey sandstones, sandy clays, fine sands, and coarser sands belonging to proluvial deposits derived from former river conical deposits.

1.2. Hydrography and Hydrogeology

The studied area falls within the basin of the Crișul Alb River and its tributary, the Cigher River. Several characteristics are noteworthy: in the plains, the drainage divides are unstable, which has facilitated the pendulation of waters between different basins; this phenomenon has been exploited for water regulation and drainage through anthropogenic measures, including the construction of new water networks.

Torrential events have been frequent, which historically conditioned periodic flooding of riverbeds.The presence of substantial and abundant flow has led to channel sedimentation and overbank flooding.

The natural discharge of the Crișul Alb is difficult to determine precisely because, during certain periods, flow deviations occur from one river to another. This results in increased minimal flow on some rivers and decreased flow on others; sometimes, Crișul Alb even reaches very low minimum discharge levels.

The Cigher River originates in the Zărand Mountains at an altitude of 521 meters, has a length of 58 km, and a basin area of 670 km². It flows into the Crișul River at Chișineu Criș. The regions of water flow regulation have required the construction of a reservoir upstream at Tăuți, in the headwaters area. The basin of the Cigher River exhibits some particularities: its average monthly flow is 20.24% in February and 17.0% in March, with flow variability between 2.78% and 0.91% from June to December, indicating significant seasonal amplitude variations.

Regarding ice formation on the Crișul Alb, recent years have seen ice layers form in the second decade of December, with ice cover lasting approximately 20 days on average.

The waters of the Crișul Alb display a high level of pollution in the main arteries; anthropogenic channels also contribute to this.

The Morilor Canal runs relatively parallel to the Crișul Alb. Its course generally follows the southern limit of the Crișul Alb's dejecție cone (causing) a rise in the groundwater level in the alluvial plain. It supplies a fishing pond located south of the town of Seleuș.

The Matca Canal (Mureș-Crișul Alb) has a maximum flow rate of 20 m³ per second at its confluence with the Crișul Alb.

1.3. Climate

The examined region is characterized by a moderate continental climate, with shorter, milder winters. It is influenced by various air mass circulation patterns, driven either by dynamic sources (the Azores anticyclone and the subtropical anticyclone) or by seasonal

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thermal centers (the Siberian anticyclone, the Asian depression, or the Mediterranean depression).

The area lies at the intersection of air masses of oceanic origin from the west, which often bring increased continental influences, and those of eastern continental origin. It is frequently under the influence of warm southern air masses crossing the Mediterranean Sea. According to Kopen's climate maps, the studied region falls within the c.f.b.x. climatic province—a moderate continental climate with oceanic and sub-Mediterranean influences.

The characterization of climatic conditions was based on climate data recorded at the Arad meteorological station.

1.4. Vegetation

From a geobotanical perspective, the studied area falls within the silvosteppe zone. In the past, oak forests covered significant areas, particularly along the Crişul River valley. Currently, isolated or small patches of Salix species, Populus alba, Fraxinus excelsior, and Robinia pseudacacia are found. Among shrubs, *Prunus spinosa, Rosa canina, Crataegus monogyna, and Ligustrum vulgare* are prevalent.

Herbaceous vegetation is characteristic of the silvosteppe zone and is typically found on soils of the Cambisol and solonetz types. These soils host indicator edaphic species such as *Statice gmelinii, Aster tripolium, Hordeum murinum, and Scorzonera laciniata*, especially on solonetz soils.

On pastures situated on Cambisols, the following species occur - *Festuca arundinacea, Festuca sulcata, Festuca pseudovina, Lolium perenne, Alopecurus myosuroides, Poa pratensis, Trifolium repens, Achillea millefolium, Plantago lanceolata, Potentilla argentea, Thymus collinus, Lepidium perfoliatum, Ononis hyrcina, Euphorbia cyparissias, Linaria vulgaris, Rumex crispus, Eryngium campestre, Onosodon acanthus, Carduus species, Medicago lupulina, Fragaria vesca, Lotus corniculatus.*

On solonetz pastures, the floristic composition includes - *Festuca sulcata, Hordeum murinum, Cynodon dactylon, Alopecurus myosuroides, Achillea millefolium, Plantago lanceolata, Trifolium incarnatum, Gypsophila muralis, Statice gmelinii, Scorzonera laciniata, Aster tripolium, Vulpia myuros, Mentha pulegium.*

Pastures on Cambisols produce satisfactory or even good yields in years with evenly distributed rainfall. Their productivity can be increased through rational grazing on plots and moderate chemical fertilization.

Pastures on solonetz soils, with impoverished vegetation, yield only in spring and autumn when the soil is sufficiently moist. During summer, these soils dry out, and plants with superficial roots struggle to penetrate the very compact Btna horizon, which leads to plant decline.

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2. SOIL RESOURCES IN TÂRNOVA COMMUNE, ARAD COUNTY

Table 1.

Soil resource inventory based on class and type of soil

No.	Soil Class	Soil Type	Area (ha)	Percentage (%)
1.	Protisol (Protisols)	Alluvial soil	2526	19.51
2.	Cambisol (Cambisols)	Eutric Cambisol	660	5.07
3.	Luvisol (Luvisols)	Preluvisol	7460	57.61
4.	Vertisol (Vertisols)	Vertosol	1036	8.00
5.	Hydrisol (Hydrisols)	Glei soil	129	1.00
6.	Soil associations	-	1140	8.81
	Total	-	12951	10

Following the pedological analyses and studies conducted in the area of interest, five main soil types were identified and classified. The first, the Alluvial Soil (Aluviosol), covers an area of 2,526 hectares, representing 19.51% of the total. This soil type develops in alluvial zones and is characterized by a variable texture and high fertility due to sediment deposits.

The second soil type, Eutric Cambisol (Eutric Cambosol), extends over 660 hectares, accounting for 5.07% of the total area. It is known for its neutral pH and nutrient-rich composition, making it suitable for intensive agriculture.

Preluvosoil (Preluvosol), the most widespread soil type in the region, occupies 7,460 hectares, or 57.61% of the total. It has a loamy-clay texture, with a good capacity for water and nutrient retention, although proper management is necessary to prevent compaction and erosion.

Vertisol (Vertosol), present on 1,036 hectares (8.00%), is distinguished by its high content of swelling clays, which confer contraction and expansion properties. Its use in agriculture is conditioned by the high traction power of machinery needed to work such soils.

Gleiosol (Gleic Soil), covering 129 hectares (1.00%), develops in conditions of excessive moisture due to the shallow and medium-depth water table, resulting in a specific pedological profile marked by the presence of a gleic horizon.

Additionally, 1,140 hectares (8.81%) are classified as soil associations, indicating a combination of different soil types within a single territorial unit, reflecting the pedological complexity of the studied zone. These data provide an essential basis for land use planning and the sustainable management of natural resources.

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3. MORPHOLOGICAL CHARACTERIZATION OF REPRESENTATIVE SOILS

3.1. Molic Alluvial Soil (Aluviosol)

Amp 0-25 cm - granulometric composition: clay-loam-medium; optical morphological properties: very dark brown to black in a moist state, shiny; very dark brownish-gray when dried; reavăn (moist soil with a shiny surface); medium-sized, well-developed, angular to subangular polyhedral structure; friable in moist condition; hard when dry; plastic; adhesive; moderately compact; small to medium-sized pores, frequently present; frequent gypsum efflorescences; Fe oxihydroxides deposited along fine root traces and forming halos around fine pores; relatively frequent coprolites; rare punctiform small concretions; numerous fine roots; transitions occur in steps.

ACGosc 25-47 cm - granulometric composition: clay-loam; optical morphological properties: dark grayish-brown with brownish-gray patches in the moist state, and grayish-brown with light brown patches when dried; reavăn; large, well-developed, angular and subangular polyhedral structure; friable when moist; hard when dry; plastic; adhesive; moderately compact; small, infrequent pores; rare ferromanganese spots; rare salt efflorescences; very frequent coprolites; very fine, rare roots; smooth, straight transition.

CkGo 47-111 cm - granulometric composition: clay-loam; optical morphological properties: yellowish-brown with frequent gray patches in moist state and light brown with frequent faint brown patches when dried; moist, shiny; massive and compact; friable in moist condition; hard when dry; plastic; adhesive; compact; small, rare pores; rare nodules and ferromanganese spots; strong effervescence in the mass; $CaCO_3$ in the form of efflorescences and rare veins; frequent coprolites; smooth, straight transition.

3.2. Typical Preluvosoil (Preluvosol)

Ap 0-17 cm - granulometric composition: clay-loam-medium; optical morphological properties: dark brown to black in moist conditions and dull brown in dry conditions; shiny-moist surface (reavăn); structure destroyed by deep agricultural work; moist, shiny surface; friable when moist; hard when dry; moderately to slightly plastic; moderately to slightly adhesive; small pores with low to moderate frequency; rare gypsum efflorescences; deposits of Fe oxihydroxides along fine root traces and forming halos around fine pores; relatively frequent coprolites; rare punctiform small concretions; numerous fine, thin roots; transitions occur gradually in steps.

AB 17-27 cm - granulometric composition: clay-loam-medium; optical morphological properties: dark brown with yellowish-brown patches in moist state; and light brown with patches in dry state; moist, shiny; structure is destroyed by drainage work; compact; friable when moist; hard when dry; moderately plastic; moderately adhesive; small, infrequent pores; numerous fine, woody roots; frequent coprolites; transitions are gradual.

BA 27-38 cm - granulometric composition: clay-medium; optical morphological properties: yellowish-brown with dark patches in moist state and dark brown with patches in dry state; moist, shiny; structure is disturbed by drainage; friable in moist condition; hard when dry; moderately plastic; moderately adhesive; small, frequent pores; rare nodules and ferromanganese spots; strong effervescence in the mass; calcium carbonate in the form of efflorescences and rare veins; frequent coprolites; clear transition.

Bt1 38-55 cm - granulometric composition: clay loam-medium; optical morphological properties: yellowish-brown with scattered patches of grayish-brown and reddish-brown in moist state, and light brown with scattered patches of olive-brown and reddish-brown in dry state; moist, shiny; massive and well developed; friable when moist; hard when dry; moderately plastic; moderately adhesive; small, infrequent pores; rare ferruginous nodules and ferromanganese spots; abrupt transition.

Bt2 55-75 cm - granulometric composition: clay-moderate; optical morphological properties: yellowish-brown with diffuse rusty and bluish patches in moist state; and light brown with scattered patches of ferruginous spots in dry state; moist, shiny; massive; friable when moist; hard when dry; strongly effervescent; calcium carbonate in the form of eflorescences and veins (rare); abrupt transition.

BCk 75-95 cm - Granulometric composition: medium clay-loam; optical morphological properties: yellowish-brown to dark yellowish-brown with brown to dark brown patches in the moist state, and yellowish-brown with brown patches when dry; moist; massive structure; friable when moist; hard when dry; exhibits strong effervescence throughout the mass; calcium carbonate present as efflorescences and rare veins; transition is gradual.

Cca 95-127 cm - Granulometric composition: medium clay; optical morphological properties: pale brown when moist and very pale brown when dry; moist; massive structure; friable when moist; hard when dry; compact structure; small, frequent pores; strong effervescence throughout the mass; calcium carbonate present as frequent vein formations along root paths and as efflorescences; transition is gradual.

2Ck 127-150 cm - Deposition of clay-loam interbedded with sands, marls, and fragments of sandstones at various stages of alteration; exhibits strong effervescence throughout the mass.

3.3. Eutric Cambisol (Batigleic)

Ap 0-25 cm - granulometric composition: clay-medium; optical morphological properties: yellowish-brown; small, poorly developed polyhedral structural units; weakly saturated; dry; clear transition;

Ao 25-36 cm - granulometric composition: medium clay; optical properties: brown; light brown; poorly developed polyhedral structure; rare, thin roots; dry; clear transition;

AB 36-56 cm - granulometric composition: medium clay; optical properties: light brown with slight yellowish hues; rare rust and bluish spots; structure is moderately developed, polyhedral and large, firm, moderately cohesive; dry; clear transition.

Bv 56-76 cm - granulometric composition: medium clay; optical properties: yellow-brown with diffused rust and bluish spots; structure is large, angular polyhedral, well developed, firm, moderately cohesive; moist; clear transition.

3.4. Calcareous-Cernic Gleiosol

Aţk Horizon (0-10 cm) - Granulometric composition: clayey loam; optical morphological properties: black when moist and very dark grayish-black when dry; moist surface; small to medium subangular polyhedral structure; friable when moist; hard when dry; plastic; adhesive; frequent small pores; very weak effervescence; very frequent fine roots; gradual transition.

Am1k Horizon (10-26 cm) - Granulometric composition: medium clay loam; optical morphological properties: black when moist and very dark gray when dry; moist surface; medium subangular polyhedral structure; friable when moist; hard when dry; plastic; adhesive; small to medium frequent pores; weak effervescence; frequent fine roots; gradual transition.

Am2k Horizon (26-45 cm) - Granulometric composition: clayey loam; optical morphological properties: black when moist and very dark grayish-black when dry; moist

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surface; medium polyhedral structure; friable when moist; hard when dry; plastic; adhesive; rare worm casts; frequent small pores; weak effervescence; frequent fine roots; gradual transition.

ACkGr Horizon (45-60 cm) - Granulometric composition: medium clay loam; optical morphological properties: very dark gray with very frequent dark olive-gray patches in moist state, and dark gray with olive-gray patches when dry; moist surface; medium to large subangular polyhedral structure; friable when moist; hard when dry; plastic; adhesive; small to medium frequent pores; ferromanganese nodules; rare roots; strong effervescence in the mass; clear transition.

Ck1Gr Horizon (60-78 cm) - Granulometric composition: medium clay loam; optical morphological properties: dark olive-gray with reddish-brown patches when moist and olive gray with reddish-brown patches when dry; moist surface; massive structure; friable when moist; hard when dry; plastic; adhesive; strong effervescence in the mass; $CaCO_3$ in efflorescences; small concretions and ferromanganese spots; rare roots; gradual-clear transition.

Ck2Gr Horizon (78-105 cm) - Granulometric composition: medium clay loam; optical morphological properties: olive gray with reddish-brown patches when moist and olive-gray with reddish-brown patches when dry; moist surface; massive structure; friable when moist; hard when dry; plastic; adhesive; strong effervescence; small concretions and ferromanganese spots; gradual transition.

Ck3Gr Horizon (105-140 cm) - Granulometric composition: medium clay loam; optical morphological properties: olive gray with yellowish-red patches in moist state and olive with yellowish-red patches when dry; moist; massive; friable when moist; hard when dry; adhesive; plastic; strong effervescence; $CaCO_3$ in the form of efflorescences; ferromanganese nodules; gradual transition.

Ck4Gr Horizon (140-170 cm) - Granulometric composition: medium clay loam; optical morphological properties: olive with yellowish-red patches when moist and olive with reddish-yellow patches when dry; moist; massive; friable when moist; hard when dry; adhesive; plastic; strong effervescence; $CaCO_3$ as veins and efflorescences; ferromanganese nodules.

BCg3 Horizon (76-102 cm) - Granulometric composition: medium clay; optical properties: yellowish with brown streaks, rusty and bluish spots; large, poorly developed, angular polyhedral structure; weakly cohesive; moist; clear transition.

Cg3 Horizon (102-161 cm) - Granulometric composition: medium sandy loam; optical properties: yellowish with rusty and bluish spots; moist; friable; clear transition.

Cg4 Horizon (161-181 cm) - Granulometric composition: fine sandy loam; optical properties: olive gray with bluish hues and rusty spots; moist; friable; wet

3.5. Mezogleic Vertosol (Strongly Gelitized)

Ap(y) 0-24 cm - granulometric composition: clayey-loamy; optical morphological properties: dark grayish-brown in moist conditions with oblique faces; structural configuration disturbed by soil work, polygonal cracks; firm, dry, with a smooth transition.

AByg2 24-38 cm - granulometric composition: clayey-loamy; optical properties: darkish black; oblique faces; rare bluish and rusty spots; structural configuration destroyed (the entire layer is a paste-like, sticky, and adhesive mass); moist, shiny.

Byg4 38-68 cm - granulometric composition: clayey-loamy; optical properties: very dark grayish-brown; oblique faces with metallic luster; bluish and rusty spots; large, moderately developed prismatic-spheroidal structure; firm, moist, shiny.

Bcyg4 68-86 cm - granulometric composition: clayey-loamy; optical properties: dark olive-gray; oblique faces with metallic luster; bluish and rusty spots; frequent nodules; large, weakly developed spheroidal structure; firm, moist, shiny.

Cyg4 86-114 cm - granulometric composition: dusty clay; optical properties: yellowish-violet with nodules; oblique faces with metallic luster; firm, moist, shiny.

Cyg5 114-166 cm - granulometric composition: sandy loam clay; optical properties: violet-yellow with oblique faces and ferromanganese accumulations; firm, moist.

Cg5 166-221 cm - granulometric composition: medium clay; optical properties: bluish-gray with ferromanganese accumulations; friable and moist.

CONCLUSIONS

A detailed analysis of the natural formation framework and the pedogenetic evolution of soils in Târnova commune, Arad County, reveals multiple critical aspects essential for understanding the dynamics of soil development in this area. The main conclusions can be summarized as follows:

The relief and geology of the region are situated within the marginal zone of the Crișurilor Plain, characterized by flat landforms and varying altitudinal terraces, shaped predominantly by subsidence processes, the retreat of the Pannonian Lake, and neotectonic activity. The presence of terraces, glacis, and deluvial deposits indicates a complex evolutionary history influenced by water level fluctuations, the regressions of the interdisjunctive sea, and erosion. These phenomena have led to the formation of deltaic landscapes, with slopes, platform terraces, and low-lying, marshy, and lacustrine zones, especially in the depressions.

Hydrogeologically and hydrographically, the basin of the Crișul Alb River and its tributary, the Cigher River, are characterized by water pendulation phenomena between the main basin and the plain area, accompanied by frequent flooding and sedimentation (colmatage). River flow regimes are seasonally variable, influenced by both natural processes and anthropogenic regulation, such as hydroelectric control measures. These processes significantly affect water resource dynamics and quality, necessitating management and environmental protection measures to ensure sustainable use.

The climate is temperate-continental, with oceanic and Mediterranean influences, featuring milder winters and warm summers. The area frequently experiences air mass incursions of various origins, including dynamic atmospheric centers (such as the Azores and subtropical anticyclones) and seasonal thermal centers (like the Siberian anticyclone, Asian depression, and Mediterranean depression). This climatic regime results in phenomena such as frost and ice formation during cold seasons, with considerable variability in precipitation, which directly impacts the water cycle and soil formation processes.

Vegetation is predominantly of the silvosteppe type, with oak forests historically occupying extensive areas along the river floodplains. Currently, solitary or small patches of species like Salix, Populus alba, Fraxinus excelsior, and Robinia pseudoacacia are present. The floristic composition, including both arboreal and herbaceous species, indicates a fragile ecological balance susceptible to anthropogenic disturbances such as deforestation and overgrazing. This diversity enhances the area's potential for sustainable pastoral and agricultural activities.

The main soil types in the study zone are preluvosoils, alluvial soils, eutric cambisols, and vertisols, covering over 12,900 hectares. Alluvial and preluvosoils are the most extensive, playing a key role in local agriculture due to their high fertility, while vertisols and gleisols pose specific challenges attributed to properties like shrink-swell behavior and waterlogging. Understanding these pedological features is fundamental for their optimal and sustainable utilization.

Morphological characterization highlights a diverse array of soil forms, ranging from alluvial and preluvosoils to slope, gleic, and calcareous soils. These differences reflect complex processes such as sediment accumulation, disintegration, moisture variation, and efflorescence, emphasizing the dynamic and intricate nature of pedogenetic development in this region.

The conclusions drawn from this pedological analysis demonstrate that the area's microrelief diversity, soil types, and geomorphological processes significantly influence the land's fertility and cultivation potential. In the context of sustainable resource management, precise pedological characterization and understanding of environmental dynamics are crucial for devising effective land-use strategies.

Accurate pedological evaluation and classification—based on morphological, physical, and chemical properties—allow for the identification of high-potential zones and areas vulnerable to degradation. Simultaneously, this approach supports the implementation of conservation, improvement, and sustainable land-use measures, which are vital for food security and environmental protection. Pedological assessments further underpin spatial planning, helping prevent resource degradation and promote responsible soil management.

Integrating pedological data into land management policies underscores the fundamental role of soil science in fostering sustainability. It contributes to optimizing resource use under ecological, economic, and social considerations, constituting an essential component for the region's long-term development. In conclusion, the precise study and classification of soils in Târnova not only facilitate responsible and efficient agricultural management but also support the development and implementation of regional policies aimed at conserving, regenerating, and sustainably valorizing environmental resources.

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